

Fishery management in a conservation area. The case of the Oiapoque River in northern Brazil

by

Sirley L. de FIGUEIREDO SILVA (1), Mauricio CAMARGO* (2) & Ruth A. ESTUPIÑÁN (2, 3)

ABSTRACT. - This study recorded the diversity of fish caught in and around the Cabo Orange National Park in northern Brazil in 2008, and estimated the fishing effort and CPUE of the local artisanal fleet. Two fishery zones – the Oiapoque River and a coastal zone – were identified. Monitoring of catches recorded 34 fish species. A PCA of the catches of the seven principal species revealed marked loadings. The first factor indicated a positive association among the monthly landings of *Plagioscion* sp., *Cynoscion virescens*, *Sciades proops*, *Notarius* spp., *Cynoscion acoupa* and *Centropomus ensiferus*. The Spearman correlation between the scores for the first PCA component and river discharge revealed a significant negative association ($\rho = -0.61$; $p < 0.05$). *Cynoscion virescens*, *Plagioscion squamosissimus* and *P. aureatus* were the target species. Profits per trip varied from US\$500 to US\$1850. It is recommended that immediate action be taken to guarantee fishery operations within the national park and surrounding areas. In this context, a Marine Extractive Reserve (MER) would allow for the sustainable use of resources and may be a more feasible approach to the situation in the Cabo Orange National Park. This type of reserve would provide coastal communities with the legal framework necessary for the co-management of the reserve.

RÉSUMÉ. - Gestion de la pêche dans une aire de conservation. Cas du fleuve Oyapock, région nord du Brésil.

Cette étude révèle la diversité des poissons capturés en 2008 dans et autour du Parc national de Cabo Orange au nord du Brésil, et estime l'effort de pêche et la CPUE de la flotte artisanale locale. Deux zones de pêche ont été identifiées : le fleuve Oyapock et la zone côtière. Le suivi des captures a mis en évidence 34 espèces de poissons. Une ACP des captures pour les sept espèces principales a révélé des relations marquées. Le premier axe indique une association positive entre les débarquements mensuels de *Plagioscion* sp., *Cynoscion virescens*, *Sciades proops*, *Notarius* spp., *Cynoscion acoupa* et *Centropomus ensiferus*. La corrélation de Spearman entre les scores du premier axe et le débit du fleuve révèle une association négative significative ($\rho = -0.61$, $p < 0.05$). *Cynoscion virescens*, *Plagioscion squamosissimus* et *P. aureatus* sont les espèces ciblées. Le revenu par sortie varie entre 500 et 1850 US\$. Il est recommandé qu'une action immédiate soit entreprise afin de garantir les opérations de pêche dans le parc national et ses environs. Dans ce contexte, une Réserve Marine Extractive (RME) permettrait l'utilisation durable des ressources et serait une approche plus réaliste compte tenu de la situation du Parc national de Cabo Orange. Ce type de réserve fournirait aux collectivités côtières le cadre juridique nécessaire à la co-gestion de la réserve.

Key words. - Artisanal fisheries - Brazil - Oiapoque River - Landings - Marine protected areas.

The estuarine and marine waters of the Atlantic coast of the Brazilian state of Amapá encompass a wealth of fishery resources (Isaac, 2006; Batista *et al.*, 2007; Oliveira *et al.*, 2007). This area includes three restricted nature reserves, in which fishing is illegal, according to Brazilian federal law 9985/2000, that regulates the National System of Conservation Units (SNUC).

The Cabo Orange National Park, located in the northern extreme of the state, is a federal protected area which includes a large portion of marine waters. Covering a total of 619,000 ha, this national park represents the largest area of the coastal waters of Brazil within a strict conservation unit. The park was created by federal decree no. 84,913 of July the 15th, 1980, with the objective of protecting the mangrove

ecosystem and the plains grasslands of the state of Amapá. Contrary to federal law 9985/2000 (SNUC), when the park was created, a number of local communities remained within its area – the villages of Cunani and Taperebá – or around its limits (the Carnot and 1° do Caciporé settlements, Vila Velha do Caciporé, and the Kumarimã and Kunanã tribes), all of which have access to the park's natural resources.

The fishery fleet of the municipality of Oiapoque has also exploited the area since the 1940s, when the park was initially given official approval. Fishing was originally concentrated within the Oiapoque estuary, where the principal target species was the croaker – *Plagioscion squamosissimus* (Heckel, 1840) and *P. aureatus* (Castelnau, 1855), although the focus eventually shifted towards the coastal waters,

(1) Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá, IEPA, Rid. J.K., km 10, s/n, Fazendinha, Macapá, AP, CEP: 68.903-000, Brazil. [sirleyfig@hotmail.com]

(2) Coordenação de Recursos Pesqueiros e Agronegócios, IFPA, Av. Almirante Barroso 1155, CEP: 66093-020, Brazil.

(3) Universidade Federal do Pará, Campus Bragança, Brazil. [ruthamanda.estupiran@gmail.com]

* Corresponding author [camargo.zorro@gmail.com]

where the primary target is the green weakfish – *Cynoscion virescens* (Cuvier, 1830). Croakers are increasingly important in local markets, where they are preferred by consumers in Macapá and Santana (Silva and Silva, 2004), while the green weakfish is the principal fishery resource landed at Amapá's ports (IBAMA, 2007a).

The principal problem for the management of the national park is related to unauthorized fishing in its coastal waters, in particular those off the mouth of the Rio Cassiporé. In 2004, an increase in the monitoring of the area by the authorities responsible for the national park (the Federal Environment Institute-IBAMA) led to conflicts with the artisanal fishermen from Oiapoque, who have traditionally exploited the natural resources of the area. In August 2007, a two-year emergency agreement was reached between the Chico Mendes Biodiversity Conservation Institute, or ICMBio – the IBAMA division currently responsible for the management of the park – and the Z-3 fishermen's cooperative from Oiapoque, with the objective of alleviating conflicts, while guaranteeing both the profit of the local fishermen and controls on their activities within the area of the park.

This agreement gave the artisanal fishermen of the Z-3 cooperative exclusive rights to the exploitation of the coastal waters of the Cabo Orange National Park. By mandating the traditional activities of artisanal fisheries within the area, the authorities hoped to increase control of the Atlantic coast of the state of Amapá, both within the limits of the national park, and in neighbouring areas. Similar “fishery agreements” have been used in other parts of the Brazilian Amazon since the 1970s as a strategy for controlling fishing activities and reducing conflicts (Almeida, 2006).

The present study aims to provide the first estimates of fishery activities and catches per unit of effort of the fleets operating in the estuary of the Oiapoque River, off the coast of the Cabo Orange National Park and in the surrounding area, as well as listing the fish species that make up the local catch. It is hoped that this diagnosis of the artisanal fishing practices in the region will provide an important database for the development of a management plan for the organization of fishery activities along the coast of the state of Amapá.

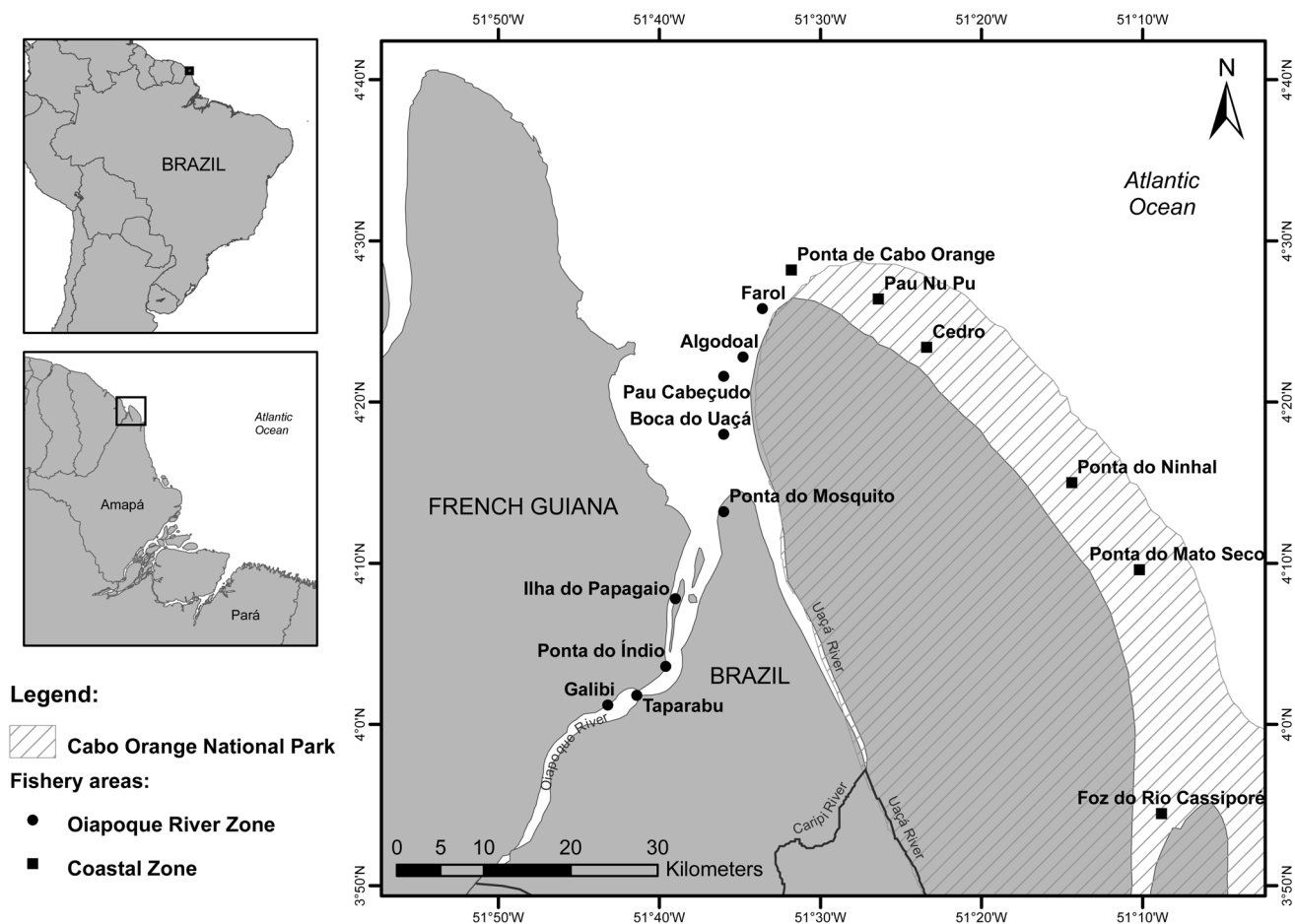


Figure 1. - The northern limit of the Cabo Orange National Park, showing the Oiapoque river and coastal fishery zones within which the Oiapoque artisanal fishery fleet operates.

MATERIAL AND METHODS

Description of the study area

The study area is part of the Guianese coast, which extends from the Oiapoque River to the North Cape (Fig. 1). The estuary of the Oiapoque is located in a low-lying coastal region with extensive tidal flats covered with mature mangrove forest. It is an area of coastal sedimentation affected by macrotides, which dissipate the mud discharged by the Amazon, brought northwards on the Brazilian Equatorial Current (Villwock, 1994).

The Cabo Orange National Park is located within the latitudes 4°26'–3°30' N, and the longitudes 51°09'–51°35' W. Of the total area of 619,000 ha, 399,734 ha are on non-flooded land, while the remaining 219,226 ha cover tidal coastal waters (Secretaria de Estado de Meio Ambiente do Amapá, unpublished data).

The park is located mainly within the municipality of Oiapoque, with a smaller portion with the municipality of Calçoene. The area is managed by the Chico Mendes Biodiversity Conservation Institute (ICMBio) of the federal government, which maintains a ranger station within the park on the Rio Caciporé, and has an administrative base in the town of Oiapoque (IBAMA, 2007b).

Location of fishing areas and description of the Oiapoque fleet

The fishing areas exploited by the Oiapoque fleet were identified by name and georeferenced using Global Positioning System (GPS). A map of the areas was generated using the ArcView GIS program.

The vessels were classified using the categories defined by the Northern Coast Fisheries Research and Management Center (MMA/ICMBio/CEPNOR, 2010). The number of vessels in each category was determined by the 2008 vessel register of the Z-3 cooperative, and confirmed by observations at the port of Oiapoque.

Landings

The composition of the fish species landed was determined using 39 questionnaires, applied randomly over the four seasons of the year. The questionnaires included the taxonomic and local names for the different species. Monthly identification of the fish species at the home port was based on Lowe McConnell, (1966), Cervigón *et al.* (1992), Planquette *et al.* (1996), Le Bail, *et al.* (2000) and validated by consulting Eschmeyer (2010). Specimens for which a reliable classification could not be obtained in the field were either collected or photographed and sent to a specialist at the Amapá State Scientific Research and Technology Institute (IEPA) for confirmation.

Catches from the study area were invariably landed in the municipality of Oiapoque, where they were purchased by

three middlemen. Following an agreement with the fishing colony, these middlemen were trained to fill in a daily roster providing information on the fish traded, including date, name of the boat, volume of fish (kg) traded per species, and price per kilogram. These rosters were collected each month by one of the researchers. The total production of the fishery fleet in 2008 was estimated through the monitoring of landings according to the name of the vessel and the volume of the catch per species and per trip during the course of a year, and summed for the municipality of Oiapoque as a whole.

Effort was calculated as a function of the number of trips per vessel during 2008. The number of vessels and fishermen (active and registered) was obtained based on landings at the middlemen and the logs of the Z-3 cooperative. Landing logs provided information such as the name of the vessel, the date, catch volume, and price per kilogram for each type of fish. Interviews with vessel owners or masters provided information on the number of days spent fishing, locations, and the number of fishermen per trip. The Catch Per Unit Effort (CPUE) was obtained by dividing the catch tonnage by the monthly number of trips monitored per vessel.

In order to define the trophic composition of the artisanal fishery landings, the trophic level of each species was identified according to Froese and Pauly (2010), and the data were plotted in a Cartesian system by month.

Data analysis

The distribution of mean CPUE values by vessel category was analysed using an ANOVA, followed by a Bonferroni multiple comparison test to identify vessels with significantly different mean CPUEs.

Mean monthly CPUEs by vessel category for all species combined were compared using ANOVA, following the application of Bartlett's test for homogeneity of variance. The homogeneous groups were defined using the Tukey post-test.

The association between catch volumes for the seven most abundant species by season was evaluated using PCA of the volume landed in each month of the study period. The relationship between the catch volume of these species and river discharge levels was investigated by verifying the correlation between the first component of the PCA and monthly river flow.

Economic parameters

Estimates of typical expenses per trip for ice, supplies and diesel were obtained through the application of 50 interviews with the owners of vessels of all the different categories. Mean profit (R\$) per trip was estimated subtracting the expenses from the gross income per catch. The gross economic return per vessel and per fisherman was calculated based on the CPUE values and the price at the first sale (fisherman-middleman).

RESULTS

Fishing zones

Based on catch composition, two distinct fishery zones were identified: (a) coastal zone – Brazilian waters between the mouths of the Oiapoque and Cassiporé Rivers, including the coastal waters of the Cabo Orange National Park, and surrounding areas. Six fishery areas were exploited in this zone. Of the 15 coastal marine species caught, the most important belong to the Sciaenidae (6 species) and the Ariidae (6 species) families; (b) Oiapoque River zone – between the Galibi indigenous village and the tip of Cabo Orange – with nine fishery areas (Fig. 1). This zone encompasses the confluence of the Oiapoque and Uaçá Rivers, on the Brazilian side, and the Ouanary River, located in French Guiana, with four fisheries, to the lower Uaçá, with five subsistence fisheries of the local Amerindians and residents of Taparabu village. In this zone, nine freshwater species are exploited, the most common being the croaker (*Plagioscion squamosissimus* and *P. aureatus*), and characiforms *Myleus setiger* Müller & Troschel, 1844, *Myleus rhomboidalis* (Cuvier, 1818), *Myloplus rubripinnis* (Müller & Troschel, 1844), *Leporinus acutidens* (Valenciennes, 1837), *Leporinus melanostictus* Norman, 1926, and *Leporinus gossei* Géry, Planquette & Le Bail, 1991.

Fishing fleet

The artisanal fishing fleet of the municipality of Oiapoque is composed of wooden vessels, most of which have no GPS or echolocation equipment (Fig. 2). A total of 106 vessels were identified in the area, 70 of which were registered at the

cooperative. Of the 81 vessels monitored in the municipality in 2008, eight were medium-sized vessels (MV) and 41 were small vessels (SV), nine were motorized canoes (MC), and 23 were motorized boats, MB (Tab. I).

The smaller vessels (SV, MC, and MV) all use gillnets with a 60 to 80 mm mesh, which are 1500 meters long and 3 m in width. These nets are set for periods of up to four hours, as many as three times a day. The larger vessels (MB) are able to spend longer periods at sea, and use gillnets with 80-100 mm plastic or nylon mesh, 2500 m in length and up to 7 m in width. These nets are also set most days for periods of three to four hours.

Six vessels were not registered in Oiapoque, but were from either the municipality of Calçoene (Amapá) or Pará state. Thirty-six vessels of the Oiapoque fleet were not matriculated in the Z-3 cooperative. Between 13 (in July) and 54 (December) vessels operated each month (Tab. II). The small boats (SV) were the most active throughout the year ($x \pm s.d.$ – 18 ± 6 vessels operating per month).

Catch volume

The total catch landed at Oiapoque in 2008 was estimated at 766.0 tons. The ANOVA for mean CPUE values by vessel category indicated significant variation ($F = 67.53 > 2.63$, $p < 0.05$). The Bonferroni test indicated that only small vessels (SVs) and motorized canoes (MCs) were not significantly different in this analysis (Tab. III).

Two distinct seasonal periods were observed. The low season, between February and September, when the river discharge was at its highest levels, was characterized by reduced catches, with a mean tonnage landed of only

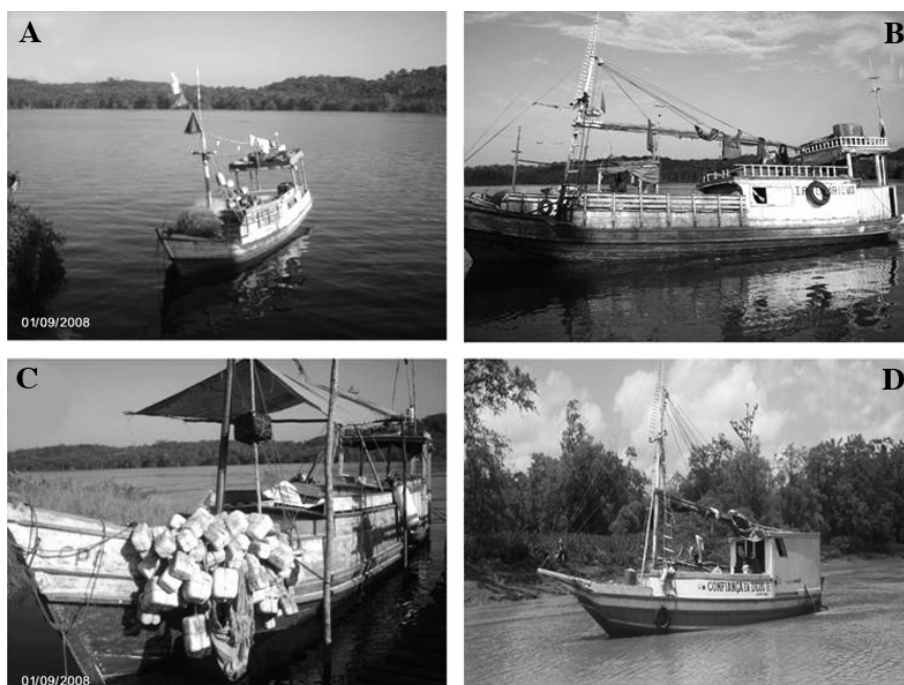


Figure 2. - Examples of the vessel categories of the Oiapoque fishing fleet. A: Motorized boat-MB; B: Medium-sized vessel-MV; C: Motorized canoe-MC; D: Small boat vessel-SV.

Table I. - Classification of the vessels in the Oiapoque fishing fleet that operate in the local fisheries zones.

Category	Code	Description
Motorized canoe	MC	Large canoe of up to 8 m in length, powered by an outboard motor or a motor and sail. May or may not have a deck.
Small boat (vessel)	SV	Wooden-hulled boat of 8-11 m powered by an engine or engine and sail, with a closed or semi-closed deck.
Medium-sized vessel	MV	Wooden- or iron-hulled boat of 12 m or more in length with closed deck and cabin. Powered by an engine or engine and sail.
Motorized boat	MB	Wooden-hulled motorized boat with keel, no deck, with or without cabin.

Table II. - Number of vessels, landings and CPUE (ton.vessel⁻¹.fishery⁻¹) recorded by vessel category in 2008 at the port of Oiapoque, Amapá. CPUE: Catch per unit effort.

Month	Medium-sized vessel			Small boat (vessel)			Motorized canoe			Motorized boat		
	Ships	Landings	CPUE	Ships	Landings	CPUE	Ships	Landings	CPUE	Ships	Landings	CPUE
Jan	3	3	1.78	25	35	1.12	7	9	0.88	11	13	0.62
Feb	3	5	1.51	11	12	0.99	1	1	0.88	8	10	0.64
Mar	4	5	1.4	20	25	0.91	4	6	1.00	9	9	0.58
Apr	4	4	1.65	15	21	0.83	4	5	0.65	7	11	0.61
May	2	2	1.44	17	19	0.93	4	4	0.86	6	6	0.54
Jun	3	3	1.62	13	17	1.04	3	3	1.34	5	5	0.83
Jul	2	2	1.33	7	8	0.78	2	2	1.02	2	2	0.67
Aug	1	2	1.68	16	22	1.19	1	2	1.54	4	5	0.75
Sept	3	4	1.91	13	18	0.86	3	4	0.98	4	4	0.68
Oct	4	6	2.62	22	36	0.99	3	4	1.31	3	4	0.79
Nov	6	8	2.22	22	30	1.09	6	8	1.1	11	16	0.75
Dec	6	6	2.30	32	42	1.14	5	6	1.16	11	14	0.68
x ± s.d.	3.4 ± 1.5	4.2 ± 1.9	1.79 ± 0.40	17.8 ± 6.8	23.8 ± 10.2	0.99 ± 0.13	3.6 ± 1.8	4.5 ± 2.4	1.06 ± 0.25	6.8 ± 3.3	8.3 ± 4.6	0.68 ± 0.09

Table III. - Multiple comparison method of Bonferroni to determine significantly different whitening the CPUEs vessel means. p: bold values indicate significant differences between the groups p < 0.005.

Relation	Mean	Standard	p	Range
MB vs. MC	-473.99	79.63	0.00	-685.14 / -262.84
MB vs. MV	-1194.08	84.15	0.00	-1417.19 / -970.97
MB vs. SV	-396.96	59.06	0.00	-553.56 / -240.35
MC vs. MV	-720.09	91.96	0.00	-963.90 / -476.28
MC vs. SV	77.04	69.74	1.00	-107.87 / 261.94
MV vs. SV	797.13	74.85	0.00	598.67 / 995.58

28.8 ± 8.1 tons per month. During the high season (January, and October through December), the mean monthly catch was 67.8 ± 11.0 tons (Fig. 3).

The SV, MV, MC, and MB category vessels were responsible for 80% of the tonnage landed at Oiapoque in 2008. The small boats (SV) were responsible for the largest part of the tonnage (289.4 tons), followed by the MVs, with 93.9 tons. Of the total tonnage, 47.11% was landed by vessels that did not belong to the Z-3 cooperative, or were from other municipalities.

Effort and CPUE

During 2008, 488 fishing trips were recorded within the study area. A smaller number of trips was recorded between February and September, whereas the last three months of the year were characterized by relatively intense activity ($x \pm s.d. = 60.0 \pm 9.1$ trips per month). By contrast, an average of only 25 trips was recorded during the previous three months. The period between February and July also returned the smallest CPUE values for the different categories of vessel (Table II).

The highest CPUE values were recorded from August onwards. The highest values were recorded for the MV category, with a monthly average of 1.79 tons per vessel per trip, in comparison with the motorized boats (MB), with a monthly mean of only 0.68 tons.

The analysis of variance revealed significant differences in the CPUE values in relation to the type of vessel and month (Tab. IV). The Tukey test indicated that the SV and MC categories formed a homogeneous group, while MB and SV were significantly different. The test also differentiated two distinct monthly groupings: a) October through December, b) all other months.

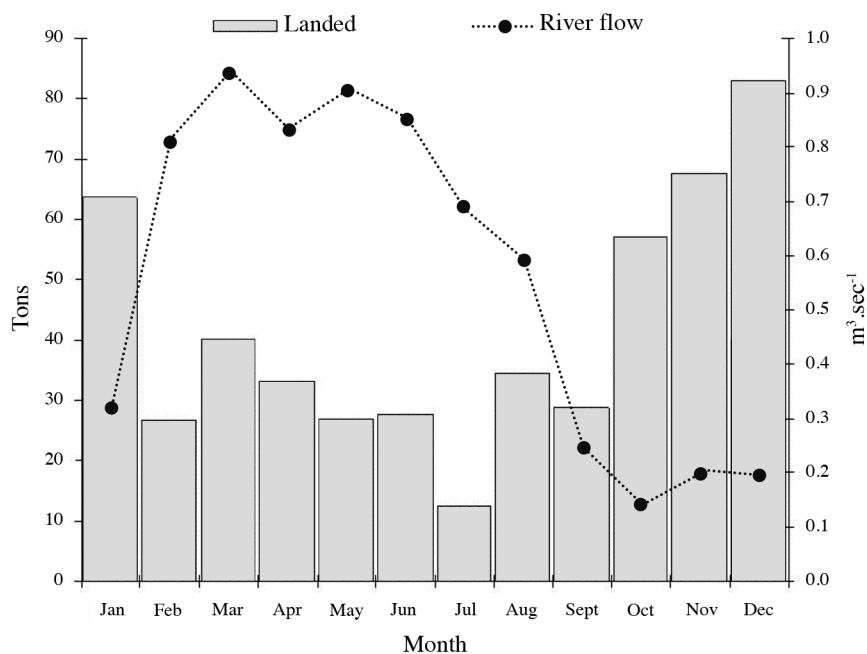


Figure 3. - Total catch tonnage and mean monthly river discharge in 2008 at Oiapoque, Amapá.

Table IV. - ANOVA for the CPUE (ton. vessel⁻¹.trip⁻¹) by vessel category and month. p: bold values indicate significant differences between the groups $p < 0.05$.

Effect	Sum of squares (SS)	Degrees of freedom (DF)	Mean square (MS)	F	p
Vessel category	40751758	3	13583919	980.61	0.0000
Month	5735727	11	521430	3.76	0.00004

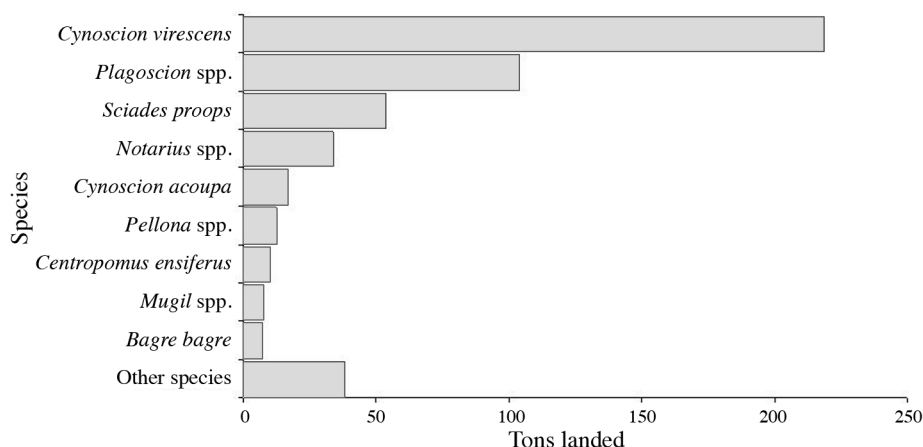


Figure 4. - Main species landed at Oiapoque, Amapá, by tonnage during 2008.

Species composition and trophic structure of the catches

A total of 34 species were identified during the study period, representing 15 taxonomic families, and eight orders. The most diverse families were the Sciaenidae (six species), Ariidae (six species), and the Pimelodidae (four species). Two of the species are found exclusively in continental waters, four can be found in estuaries, nine are coastal-estuarine, 11 strictly coastal, while *Megalops atlanticus* Valenciennes, 1847 is found in both continental and coastal waters (Tab. V).

The croaker, *Plagioscion squamosissimus* was the tar-

get species in the Oiapoque River fishery zone. The bycatch included freshwater and marine-estuarine fishes, such as pacus, *Myleus rhomboidalis* and *Myleus setiger* and catfish, *Notarius* spp., respectively.

In the coastal zone, the target species was the green weakfish, *Cynoscion virescens*, which was taken together with other commercially-valuable species, such as the acoupa weakfish, *Cynoscion acoupa* (Lacepède, 1801), snook, *Centropomus ensiferus* Poey, 1860, and the crucifix sea catfish, *Sciades proops* (Valenciennes, 1840).

Table V. - Diversity of fish species landed at Oiapoque during 2008.

Species	Local name	Trophic level ± s.e	Oiapoque River zone		Coastal zone
			river	bay	
<i>Bagre bagre</i> (Linnaeus 1766)	Bandeirado	4.01 ± 0.66			X
<i>Sciades parkeri</i> (Traill 1832)	Gurijuba				X
<i>Sciades proops</i> (Valenciennes 1840)	Uritinga	4.35 ± 0.77			X
<i>Aspistor quadriscutis</i> (Valenciennes 1840)	Cangatá	3.50 ± 0.37	X	X	
<i>Notarius grandicassis</i> (Valenciennes 1840)	Cambéua	3.63 ± 0.40		X	X
<i>Amphiarius rugispinis</i> (Valenciennes 1840)	Jurupiranga	3.57 ± 0.39		X	X
<i>Brachyplatystoma filamentosum</i> (Lichtenstein, 1819)	Filhote	4.47 ± 0.79		X	X
<i>Brachyplatystoma vaillantii</i> (Valenciennes, 1840)	Piramutaba	4.50 ± 0.80	X	X	X
<i>Pimelodus blochii</i> Valenciennes, 1840	Mandi	3.11 ± 0.43	X	X	
<i>Mugil curema</i> Valenciennes 1836	Curimã	2.01 ± 0.04		X	X
<i>Mugil incilis</i> Hancock 1830	Pratiqueira	2.01 ± 0.03		X	
<i>Cynoscion virescens</i> (Cuvier 1830)	Corvina	4.03 ± 0.70			X
<i>Cynoscion acoupa</i> (Lacepède, 1801)	Pescada amarela	4.50 ± 0.32			
<i>Macrodon ancylodon</i> (Bloch & Schneider 1801)	Pescada Gó	3.90 ± 0.65		X	X
<i>Micropogonias furnieri</i> (Desmarest 1823)	Curuca	3.26 ± 0.48			X
<i>Plagioscion auratus</i> (Castelnau, 1855)	Pescada branca	3.54 ± 0.48	X	X	
<i>Plagioscion squamosissimus</i> (Heckel, 1840)	Pescada branca	4.35 ± 0.77	X	X	
<i>Scomberomorus regalis</i> (Bloch 1793)	Serra	4.48 ± 0.79			X
<i>Lobotes surinamensis</i> (Bloch 1790)	Caraçu	4.04 ± 0.71			X
<i>Centropomus ensiferus</i> Poey 1860	Camorim	3.96 ± 0.68			X
<i>Caranx hippos</i> Günther 1867	Xaréu	3.50 ± 0.49		X	X
<i>Genyatremus luteus</i> (Bloch 1790)	Peixe Pedra	3.50 ± 0.50			X
<i>Megalops atlanticus</i> Valenciennes, 1847	Pirapema	4.50 ± 0.80	X	X	X
<i>Myleus setiger</i> Müller & Troschel 1844	Pacu	2.00 ± 0.00	X		
<i>Myleus rhomboidalis</i> (Cuvier 1818)		2.67 ± 0.37			
<i>Myloplus rubripinnis</i> (Müller & Troschel 1844)		2.00 ± 0.00			
<i>Leporinus acutidens</i> (Valenciennes 1837)	Aracu	2.05 ± 0.18	X		
<i>Leporinus melanostictus</i> Norman 1926		2.04 ± 0.18			
<i>Leporinus gossei</i> Géry, Planquette & Le Bail 1991		2.08 ± 0.19			
<i>Dasyatis americana</i> Hildebrand & Schroeder 1928	Arraia	3.51 ± 0.59		X	X
<i>Pellona harroweri</i> (Fowler 1917)	Sarda	4.20 ± 0.73		X	X
<i>Pellona flavipinnis</i> (Valenciennes 1837)		4.50 ± 0.80		X	X
<i>Carcharhinus</i> spp.	Cação	4.31 ± 0.70			X

The green weakfish (*Cynoscion virescens*) and the croacker (*Plagioscion squamosissimus*) were the most abundant species in catches overall, followed by the crucifix catfish (*Sciades proops*) and sea catfish (*Notarius* spp.), in addition to commercially valuable species such as the acoupa weakfish (*Cynoscion acoupa*) and snook, *Centropomus ensiferus* (Fig. 4).

The analysis of variance for the CPUEs of *Cynoscion virescens* indicated significant differences by month ($F = 2.034$, $p < 0.05$), and vessel category ($F = 20.384$, $p < 0.05$) (Tab. VI). The Tukey test indicated that September and October constituted a homogeneous group (1), as did the remaining months (2), while three homogeneous vessel groups were identified: SV and MC₍₁₎, MB₍₂₎, and MV₍₃₎.

Table VI. - Analysis of variance of the square root of the catches landed of green weakfish and croaker by different categories of vessel each month over the study period (January-December, 2008). p: bold values indicate significant differences between the groups $p < 0.05$.

Species	Factor	Sum of squares (SS)	Degrees of freedom (DF)	Mean square (MS)	F	p
<i>Cynoscion virescens</i> (Corvina)	Vessel category	7586.53	3	2528.84	20.384	0.0000
	Month	2776.00	11	252.36	2.034	0.0245
	Residual	45033.09	363	124.06		
<i>Plagioscion</i> spp. (Pescada branca)	Vessel category	0.5287	3	0.1779	1.779	0.1521
	Month	43.175	11	0.3925	3.961	0.0000
	Residual	219.972	222	0.0991		

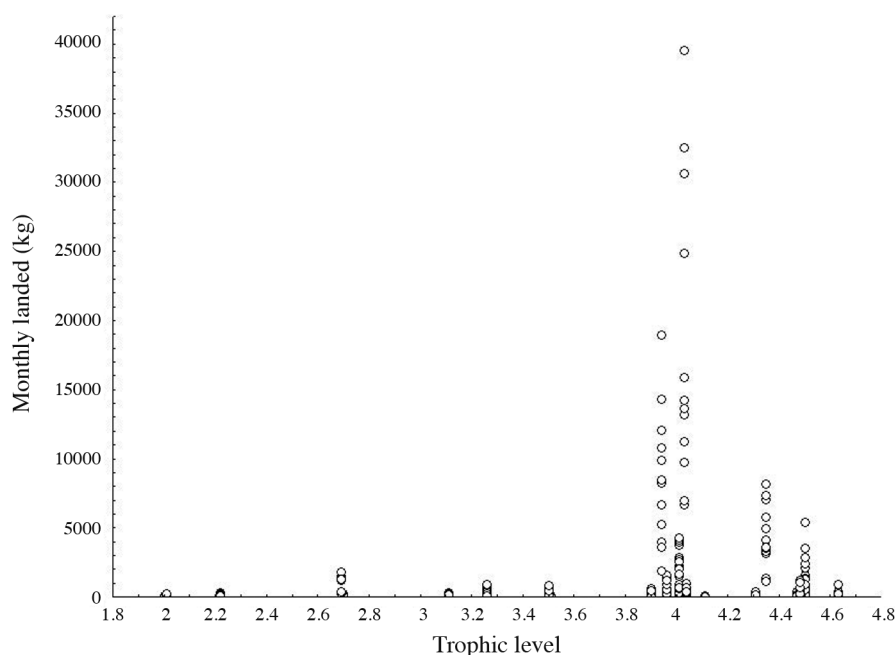


Figure 5. - Volume landed per month by trophic level of the fish species.

For the CPUEs recorded for the croaker (*Plagioscion* spp.), the ANOVA found no systematic pattern in relation to vessel category, but significant differences among months, $F = 1.779$, $p < 0.05$ (Table VI). The Tukey test identified five homogeneous groups of months: 1) January, 2) February, March, April, July, and September, 3) May, 4) June, 5) August, October, November, and December.

The principal fish species landed during this study were predators from the higher trophic levels of the food web (Fig. 5).

Association of catch volumes among species

The principal components analysis of the catches of the seven principal species revealed marked loadings for values greater than 0.65. The first factor explained 61.84% of the variation, and indicated a positive association among the monthly landings of *Plagioscion* sp, *Cynoscion virescens*, *Sciades proops* (Valenciennes, 1840), *Notarius* spp., and *Centropomus ensiferus* (Fig. 6). The second factor accounted a further 19.25% of the variability, and confirmed that

Table VII. - Factor loadings for the principle components analysis of the seven most abundant species by monthly landing volumes. Bold values indicate positive correlation. Marked loadings are > 0.65 .

Species	Factor 1	Factor 2
<i>Cynoscion virescens</i>	0.91	-0.25
<i>Plagioscion</i> sp.	0.87	0.14
<i>Sciades proops</i>	0.92	0.29
<i>Notarius</i> spp.	0.92	0.07
<i>Cynoscion acoupa</i>	0.68	-0.01
<i>Pellona</i> sp.	0.15	0.97
<i>Centropomus ensiferus</i>	0.75	-0.49
Variation explained (%)	61.84	19.25

Pellona spp. were responsible for most of the variation in landings in different form (Tab. VII; Fig. 6). The Spearman correlation between the scores for the first PCA component and river discharge revealed a significant negative association ($\rho = -0.61$; $p < 0.05$). In other words, the species asso-

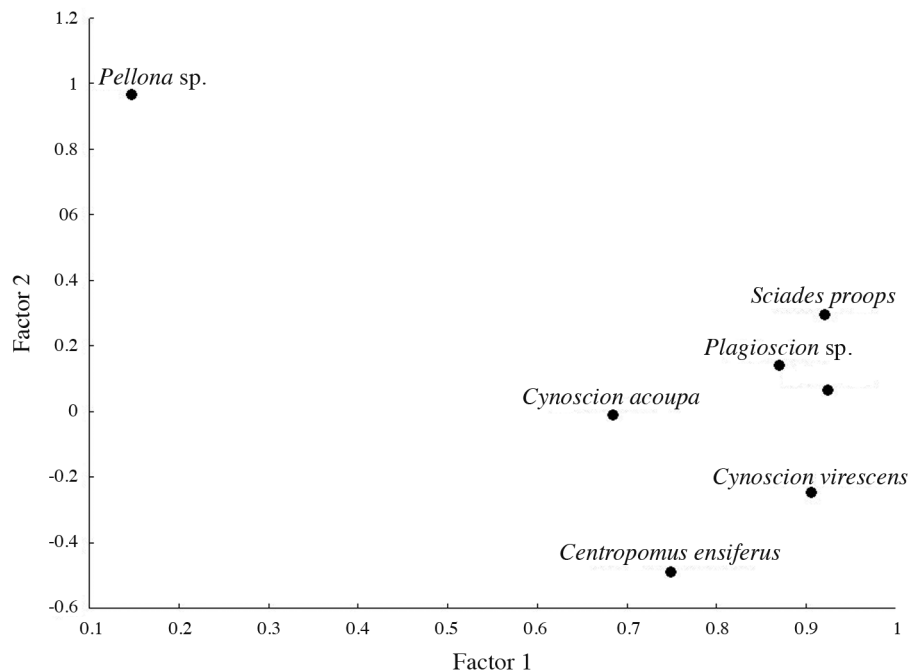


Figure 6. - Analysis of the two principal components for the most abundant species landed at the port of Oiapoque in 2008.

ciated with the first component were landed in larger quantities during the period of lower flow (Fig. 7)

Gross income and profit

The profit per vessel varied from 1.8 to 6.8 minimum wages (approximately US\$500 to US\$1850 per trip). The vessels with the largest cargo capacity and best navigability (MV) were also those having the highest economic returns per trip in relation to the category MB, which in turn was higher than those of the categories SV and MC (Tab. VIII).

Table VIII. - Mean gross and profit per trip by vessel category in 2008 in the Cabo Orange National Park.

Category	Gross profit (R\$) per trip $\bar{x} \pm \text{s.d.}$	Net profit (R\$) per trip $\bar{x} \pm \text{s.d.}$	Number of minimum wages (US\$)
MV (n = 6)	4.060 \pm 139	3.120 \pm 1.055	6.8
MC (n = 5)	2.450 \pm 331	1.760 \pm 261	3.8
SV (n = 30)	2.076 \pm 477	1.513 \pm 359	3.3
MB (n = 9)	1.100 \pm 122	826 \pm 108	1.8

Table IX. - Mean (\pm standard deviation) income of vessel owners and crew members per trip.

Category	Owner (R\$)	Crew (R\$)	
		Crewman	Fisherman
MV (n = 6)	1.560 \pm 528	672 \pm 89	336 \pm 89
MC (n = 5)	884 \pm 130	296 \pm 28	236 \pm 28
SV (n = 30)	756 \pm 179	289 \pm 61	229 \pm 53
MB (n = 9)	413 \pm 54	137 \pm 18	137 \pm 18

Estimated mean income of crewmen

The standard arrangement for the distribution of the income of a fishing trip in the Oiapoque fleet is a division between the vessel's owner, who receives half of the amount, and the rest of the crew, who share the other half. Crew members may receive different portions of this share, according to their responsibilities. In addition to the fishermen themselves, there may be a master, helmsman, and an iceman, who is responsible for the storage of the catch.

While the master or helmsman of a larger boat (MV) typically receives a double share, in recognition of his greater duties and responsibilities during the trip, the normal practice on SV and MC category vessels is to divide the share equally among the crew members. In the MB category, differential shares are paid only in certain special situations. The variation in the mean income of vessel owners, crewmen (masters, helmsmen, and icemen), and fishermen per trip in 2008 is presented in table IX.

DISCUSSION

Hydrological cycle and fisheries

The Cabo Orange National Park represents one of the few coastal ecosystems that are directly affected by the discharge of the Amazon. This littoral receives the bulk of the discharge of the Amazon, as well as that of smaller rivers such as the Oiapoque and Maroni, which determines the low salinity and very high turbidity of the coastal waters (Gibbs, 1976). The impact of this fluvial input has been well studied

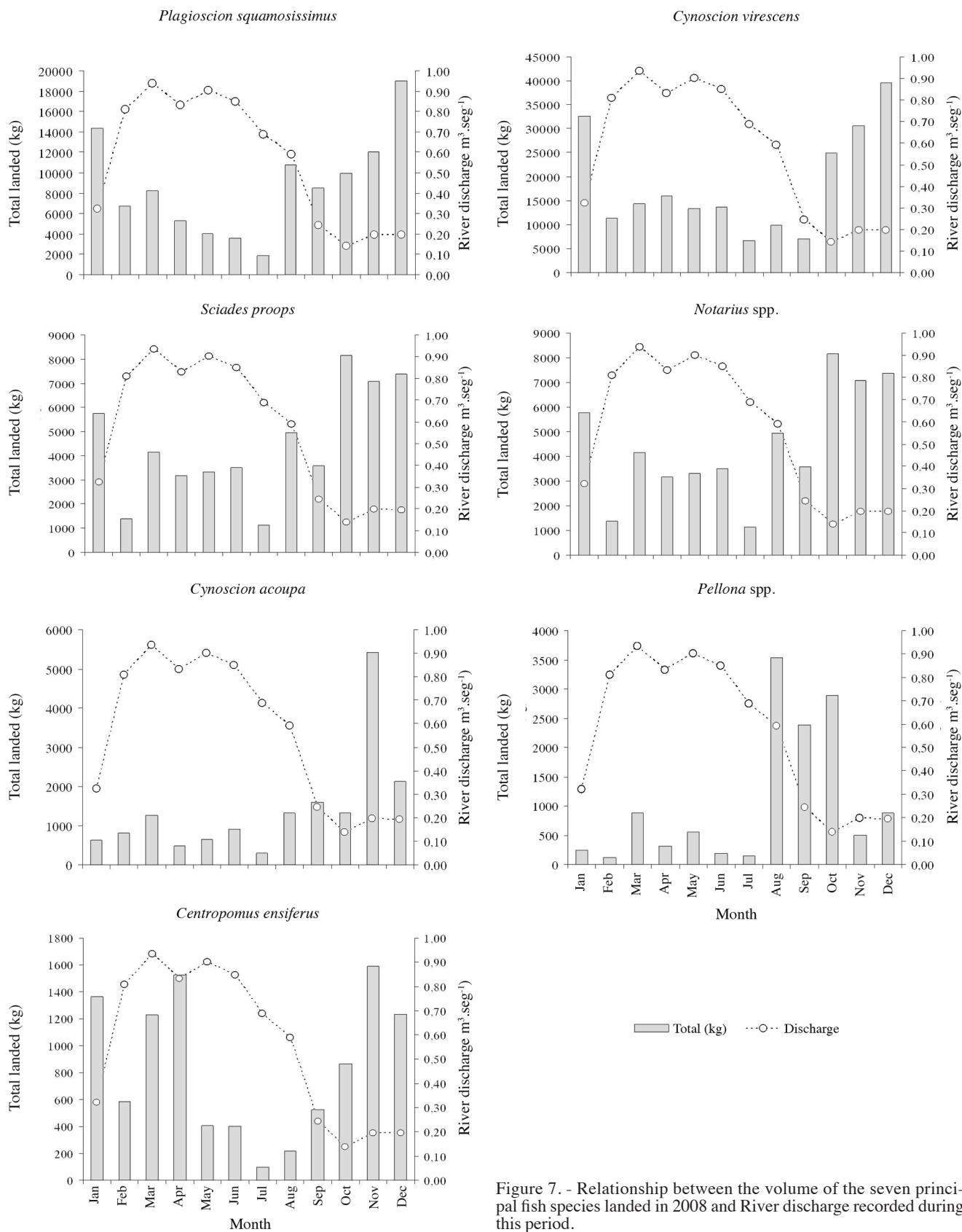


Figure 7. - Relationship between the volume of the seven principal fish species landed in 2008 and River discharge recorded during this period.

in terms of its effects on salinity, temperature, turbidity, and sediment quality (Ryther, 1967; Abbes *et al.*, 1972; Castaing and Pujos, 1976; Bouysse *et al.*, 1977).

The fish species of commercial interest within the area of the national park can be characterized as eurytypical given their tolerance of high turbidity (Lowe McConnell, 1962; Camargo and Isaac, 2001) and ample variation in salinity – which falls to values below 25 ppm at depths of 30 m (Abbes *et al.*, 1972) – as well as adaptations for habitats with muddy bottoms (Guéguen, 2000). However, this study showed that the artisanal fisheries of the Oiapoque focus on demersal species of the Scianidae and Ariidae, which typically occupy estuaries and river mouths in northern South America (Cervigón *et al.*, 1992; Camargo and Isaac, 2001).

River discharge had a negative effect on the landings of some species exploited. Between October and December, when the discharge was greatest, catches of *Plagioscion* spp. were smaller, while they were much larger between February and July. A similar pattern was recorded for *Cynoscion virescens*, which returned the largest catches in September and October. The fishery production presented a clear harvest period, which appears to be related to the hydrological cycle. A similar pattern of relatively high landing volumes during the dry season has been recorded for the Bragantine region of the state of Pará, Brazil (Isaac *et al.*, 2010).

Studies of the fish assemblages of other tropical South American estuaries have found that seasonal changes in composition are determined primarily by fluctuations in salinity levels associated with that in rainfall. Fluctuations in salinity influence the seasonal movements, reproduction and recruitment of many estuarine, marine and freshwater fish species, and define seasonal changes in catch rates in estuaries of Guyana (Lowe-McConnell, 1987) and northern Brazil (Batista and Rêgo, 1996; Camargo and Isaac, 2005).

The positive association observed between the CPUE values for *Plagioscion* and some coastal species, appears to reflect a response to the reduction in the discharge of the Oiapoque, and a consequent increase in the salinity of the water within the mouth of the river, which may facilitate the access of coastal species to the estuary, where they become more vulnerable to the fishing fleets. The composition of the fish species landed during the present study indicated the coexistence of many marine and/or freshwater fishes with resident species.

The main fish species landed during this study were predators from the higher levels of the food web. This emphasized the importance of continued monitoring of the trophic structure of landings as an indicator of possible over-exploitation (Pauly *et al.*, 1998).

The official estimate for 2005 (FUNDAÇÃO PROZEE/SEAP/IBAMA, 2006) relates the presence of a fishing fleet of 66 vessels operating within the study area and landing their catches in Oiapoque. This figure represents 12% of the

total fishing fleet of the state of Amapá. In the present study, 106 vessels were recorded, of which only 70 are registered with the Z-3 cooperative, which means that approximately a third of the fleet currently operating within the area is not including in the fishery agreement signed in 2007 by the Oiapoque cooperative and the administration of the Cabo Orange National Park. Furthermore, the vast majority (over 90%) of the vessels registered with the cooperative belong to the smaller size categories (MB, SV, and MC).

An important factor that limits the potential for the effective regulation of the state's fishing fleet is the centralization of the administrative organs responsible for the emission of documents and permits in the capital, Macapá, which is almost 600 kilometres from Oiapoque. This means that the involvement and commitment of local entities, such as the administration of the Cabo Orange National Park (ICMBio), the Oiapoque fishery cooperative, the Amapá state fishery federation, the Brazilian Navy (port authority), and the presidential special secretary, among others, will be essential for the regulation of the Oiapoque fleet.

The total catch estimated for Oiapoque in 2005 by FUNDAÇÃO PROZEE/SEAP/IBAMA (2006) was 400 tons, or 8% of the total marine-estuarine production for the state of Amapá. In the present study, this estimate was 766 tons for 2008, an apparent increase of almost 100% over 2005. It seems likely, however, that this difference was more to an underestimate in the official figure for 2005, rather than an actual increase in tonnage, given that this value was based on a mean derived from a sample of catches.

The accuracy of the estimate of the total catch would thus be vulnerable to that of the number of vessels in operation. An additional source of error would likely be the considerable variation in the performance of vessels of different categories – especially those of small size – as observed in the present study. Similar discrepancies in the official estimates of fishery production in marine and estuarine zones were recorded in the Amazonian municipality of Bragança by Isaac *et al.* (2008), who also questioned the sampling procedures adopted by the government agency responsible for the figures.

The present study indicates the need for an adjustment in procedures, in particular, the adoption of sampling methods that take the type of vessel and its potential capacity into account. The accuracy of estimates would likely be improved considerably by the adoption of a random sampling schedule structured by vessel category.

The characterization of fishery zones in relation to the estuarine-coastal gradient may represent a potentially important strategy for the management of fishery resources through the definition of periods appropriate for the exploitation of ecologically distinct species, adapted to freshwater-estuarine or coastal habitats, for example. The development of such strategies in areas such as that of the Oiapoque would have

to take into account factors such as vessel category, storage capacity, and autonomy.

Some of the fisheries on the Oiapoque are located at the limit of the international waters of French Guiana, and some vessels are known to encroach these limits. The role of the Oiapoque as an international frontier makes it especially vulnerable to territorial conflicts between fishing fleets, especially in relation to the demarcation of fishery zones. Given this, the official regulation of the use of river channels and estuaries, and the practice of subsistence and small scale artisanal fishing by local residents is especially important.

One recommendation is that, as an immediate measure, access to the national park and surrounding areas should be guaranteed, and monitored through an official agreement for a period of two years. In the short term, the development of joint actions involving entities related to the sector, such as federal and/or state attorney offices, would be useful to expedite the registration of vessels and fishermen, and guarantee the promotion of regulatory measures.

It would also be necessary to actively promote the importance of vessel registration and controls within the local community, involving primarily the fishery cooperative and ICMBio. This would both help guarantee the access of the local fleet to the area of the national park, and restrict that of fisheries from other municipalities.

Over the long term, one potential strategy which would contribute to the reduction of pressure on the natural resources of the national park would be an upgrading of vessels from the small boats that predominate at the present time (in particular SVs) to larger boats (e.g., MVs) with greater autonomy, which would be able to operate effectively outside the limits of the national park. This would obviously require a concerted effort from all the parties involved, at different levels of organization.

The role of Cabo Orange National Park as a marine protected area

The establishment of Marine Protection Areas (MPAs) like that of the Cabo Orange National Park in northern Brazil can improve fishery yields (Gell and Roberts, 2003; McClanahan *et al.*, 2006). Extensive empirical evidence has demonstrated that the use of MPAs has led to increases in the abundance, body size, biomass and reproductive output of exploited species worldwide (Polunin and Roberts, 1993; Unsworth *et al.*, 2007), as well as benefiting adjacent fisheries and the diversity and abundance of fish assemblages (McClanahan and Mangi, 2000; Russ *et al.*, 2003; Russ *et al.*, 2005). However, few studies have focused on the social implications of this strategy for local communities and other stakeholders who depend on fishery resources for their livelihood (Diegues, 2008).

The Cabo Orange National Park in northern Brazil is a good example of an MPA created in a top-down manner

without considering the elements required for the long-term benefit of coastal communities. The establishment of this protected area has led to conflicts between artisanal fishermen and administrators, mostly due to restrictions on catches in traditionally-used areas.

A similar case can be seen in the Peixe Lagoon National Park in southern Brazil, which was established in 1986, and in the northeastern Lençóis Maranhenses National Park of, founded in 1981, which were created without consulting local fishing communities or encouraging their participation (Adomilli, 2006; D'Antona, 2000). Studies from Brazil, India, Mexico, South Africa, Tanzania, and Thailand have documented the costs to communities in terms of lost livelihood options, expulsion from traditional fishing grounds and living spaces, and violation of human rights or community benefits (Diegues, 2008).

These examples indicate that an MPA may be both a "biological success" and a "social failure", where the needs and involvement of local communities are ignored (Diegues, 2008). Given this, it is essential to guarantee not only the conservation of an area's biodiversity and ecosystems, but also the integration of poor local communities that depend on natural resources for subsistence.

In this context, a Marine Extractive Reserve (MER) – would allow for the sustainable use of resources (Cordell, 2007) – may be a more feasible approach to the situation in the Oiapoque. This type of reserve would provide coastal communities with the legal framework necessary for the co-management of the reserve. The most positive examples of this livelihood-sensitive conservation approach can be found in Brazil, where many traditional communities have demanded the implementation of MERs (Diegues, 2008).

The major challenge here is the integration of traditional management practices in the overall management of an MER. Information on artisanal catches can provide the basis for the development of appropriate fishery management practices but very few reliable data are available for the Oiapoque River. The training and deployment of local personnel for the collection and processing of data may be vital here. These data can also complement information on other aspects of the catch provided by the middlemen. In Brazil, an increasing number of fishery biologists are involved in the study of traditional systems of knowledge (ethnoscience or cognitive anthropology), in some cases within MERs. However, the expertise necessary to transform this traditional knowledge into management tools is still scarce.

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